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The Genus *Roboastra* Bergh, 1877 (Nudibranchia: Polyceridae: Nembrothinae) in the Atlantic Ocean

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The systematics of the phanerobranch dorid genus *Roboastra* Bergh, 1877 in the Atlantic Ocean is reviewed. *Roboastra europaea* García-Gómez, 1985 is redescribed and its geographical range updated. *Roboastra caboverdensis* sp. nov. is described from material from Cape Verde Archipelago. The two species differ in their color pattern. The arrangement of the yellow lines or bands differs between the two species with denser lines in *R. europaea*. The base of the rachidian radular tooth is more curved in *R. caboverdensis* than in *R. europaea* and the upper cusp of the inner lateral tooth is bifid in *R. europaea* while in *R. caboverdensis* it is simple.

Se revisa la sistemática del género del dórido fanerobránquio *Roboastra* Bergh, 1877 en el Océano Atlántico. Se redescribe *Roboastra europaea* García-Gómez, 1985, así como se actualiza su distribución geográfica. Se describe *Roboastra caboverdeusis* sp. nov a partir de material procedente del archipiélago de Cabo Verde. Las dos especies se diferencian por su patrón cromático. La disposición de las líneas o bandas amarillas difiere entre las dos especies, con un mayor número de ellas en *R. europaea*. La base del diente radular raquídeo está más curvada en *R. caboverdeusis* y la cúspide superior del diente lateral interno es bífida en *R. europaea* mientras que en *R. caboverdeusis* es simple.

The genus *Roboastra* was described by Bergh (1877). Until Burn´s revision (1967), this genus included three species: *Roboastra gracilis* (Bergh, 1877) (type species), *R. rubropapulosa* (Bergh, 1905) and *R. luteolineata* (Baba, 1936), all with an Indo-Pacific distribution. Burn described a new species, *R. arika* and suggested that *R. rubropapulosa* should be considered as a synonym of *R. gracilis*. Some years later, Farmer (1978) described *R. tigris* from the eastern Pacific. García-Gómez (1985) then described *R. europaea* from the Strait of Gibraltar, the only species known from Atlantic-Mediterranean waters. Thus, to date, the genus *Roboastra* includes five named species. The only morphological data stem from the original descriptions, with the exception of the redescription of *R. gracilis* by Burn (*op. cit.*) and its taxonomic comparison with *R. luteolineata* by Hamatani and Baba (1976).

No additional studies have treated members of this genus except for that of *R. tigris* (Carté and Faulkner 1983, 1986) and, more recently, in which *R. europaea* was the focus of molecular phylogenetic (Grande *et al.*, 2002) and feeding ecology (Megina and Cervera 2003) studies. Recent collections from the Cape Verde Archipelago (West Africa) have yielded several specimens of a second undescribed Atlantic species of this genus.

In this paper, we describe the new species from Cape Verde. We also redescribe *R. europaea,* largely from material from the Iberian Peninsula, and update its geographical range.

Material and methods

Specimens were dissected by dorsal incision. At least three specimens of each species were examined anatomically. Their internal features were examined and drawn under a dissecting microscope with a camera lucida. Particularly interesting soft parts were critical-point dried for scanning electron microscopy (SEM). Special attention was paid to the morphology of the reproductive system. The buccal mass was removed and dissolved in 10% sodiun hydroxide until the radula was isolated from the surrounding tissue. The radula was then rinsed in water, dried, and mounted for examination by scanning electron microscopy.

The materials examined are deposited in the California Academy of Sciences, San Francisco (CASIZ), the Museo Nacional de Ciencias Naturales, Madrid (MNCN) and the Museu Municipal de Funchal (Historia Natural) (MMF).

Species descriptions

Family Polyceridae Alder and Hancock, 1845
Subfamily Nembrothinae Burn, 1967

Genus *Roboastra* Bergh, 1877

***Roboastra europaea* García-Gómez, 1985**
(Figs. 1A, 2, 3A–C, 4, 5, 6)

Material examined.— MNCN 15.05/46612. 1 specimen, 10 m depth, Torre, Marbella, Spain, July 1995, J.L. González, 30 mm. CASIZ 166049. 1 specimen, 10 m depth, Torre, Marbella, Spain, September 1995, M.T.Barrea, 18 mm. CASIZ 166053. 2 specimen, Torre, Marbella, Spain, August 1996, K.L. Schick, 10.7m, 15 y 19 mm. MNCN 15.05/29203, 1 specimen, La Herradura, Granada, Spain, February 1993, A.Barrajón and M. Zarauz, 14 mm. MMF 31021, 1 specimen, 100 m depth, Funchal, Madeira, June 1999, 35 mm. MNCN 15.05/46613. 1 specimen, 20 m depth, Ponta de Baleeira, Sagres, Portugal, July 2002, M.Pola, 14 mm. MNCN 15.05/46613. 1 specimen, 20 m depth, Ponta de Baleeira, Sagres, Portugal, July 2002, M.A. Malaquias, 10 mm. Specimens were collected on rocks and were measured preserved.

Distribution.— This species is known mainly from the Strait of Gibraltar and southern Iberian Peninsula (García-Gómez 1985; 2002[1]; Cervera et al. 1988; García-Gómez et al. 1989, 1991; Moreno and Templado 1998; Schick 1998; Megina 2000; Ocaña et al. 2000; Sánchez-Tocino et al. 2000; Grande et al. 2002; Megina and Cervera 2003). One misidentified specimen of *Plocamopherus* from Madeira deposited at the Natural History Museum (London) (Reg. No. 1863.9.19.3), supposedly collected by Rev. R. Lowe, was correctly identified as belonging to *Roboastra*, very probably *R. europaea*. This conclusion has been strongly supported by the recent collection of one specimen (also photographed) of this species at Funchal Harbour.

This species has been also recorded in southwestern Portugal (Calado et al. 2002) and Catalunian coasts (northeastern Iberian Peninsula, Mediterranean Sea) (K.L. Schick, pers. commun.).

[1] The specimens described by García-Gómez (2002) are the same of those described by this author in 1985 for the original description of this species.

External morphology (Fig. 1A).— The body is elongate and limaciform. The preserved animals are 10–40 mm in length. The body surface is lightly uneven with the edge of the mantle not sharply angled. Foot is linear with a pointed posterior end of the foot. The head is rounded with a pair of perfoliate rhinophores (bearing 30–35 lamellae) that are completely retractile into their sheaths. The oral tentacles are well developed and grooved dorsolaterally along a part of their

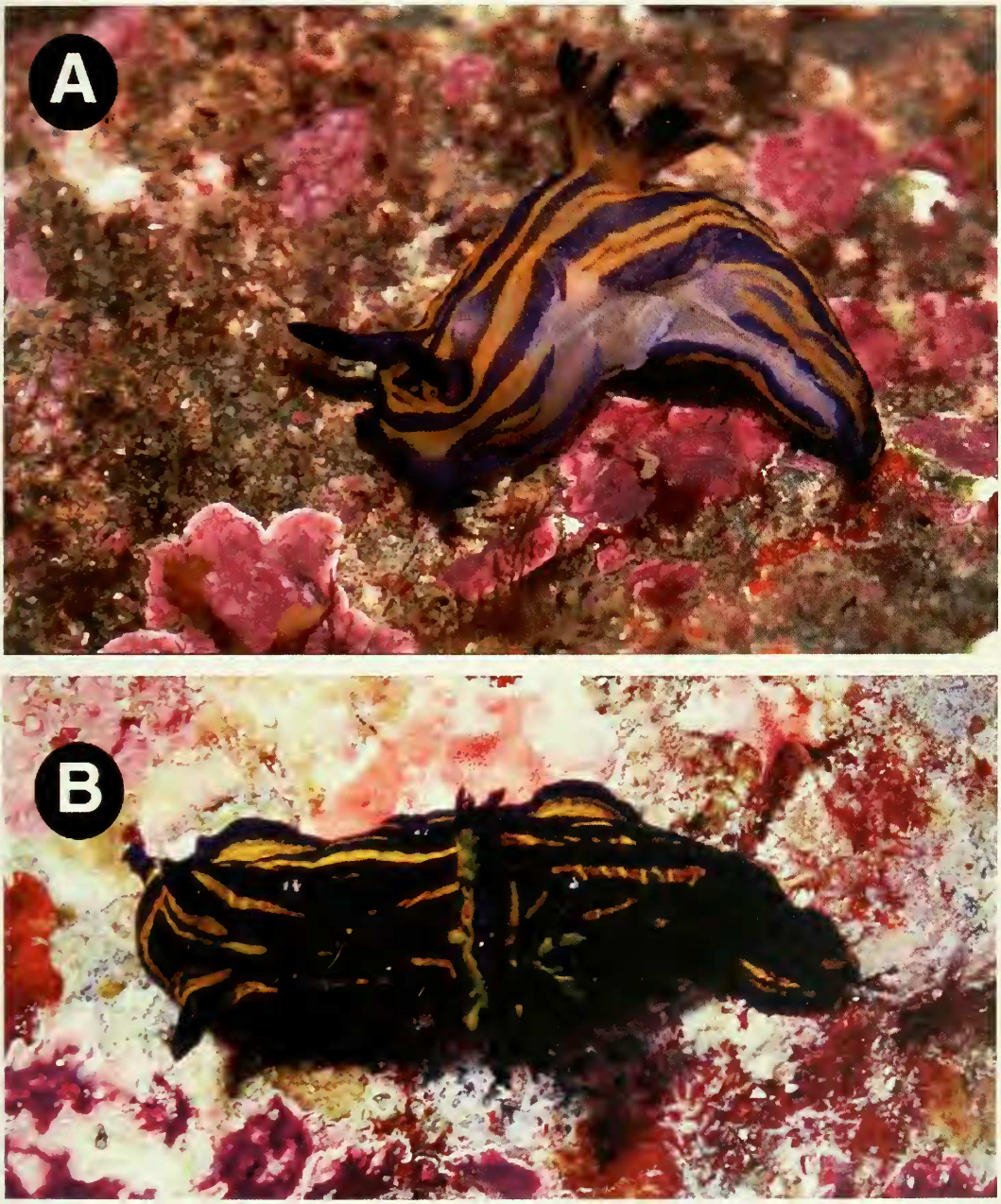
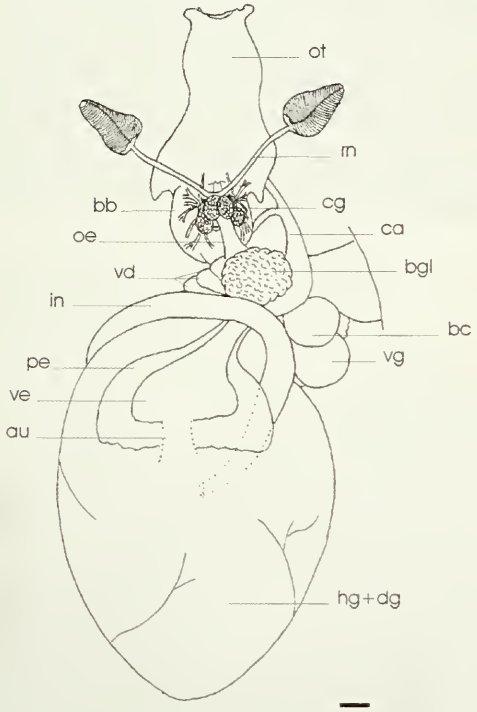


FIGURE 1. Living animals. A. *Roboastra europaea* García-Gómez, 1985, specimen from Ponta da Baleeira, Sagres, Portugal. B. *Roboastra caboverdensis* sp. nov., specimen from Banco Joao Valente, Ilha da Boavista, Cape Verde.

length. There are five non-retractile, bipinnate gills surrounding the anal papilla and forming a half circle; the three central gills are larger than the two lateral ones. The genital aperture is located midway between the gills and rhinophores, on the right side. The body wall is highly muscular. Regarding the color pattern, this species can exhibits two color phases. One of them has a grey or bluish grey ground color; the other has dark blue ground color. Both phases have several yellow or yellowish orange bands on the notum and both sides of the body. These bands are variable in number, shape, length and width. The rhinophores and oral tentacles are grey/bluish grey to dark blue. The inner side of the gill rachis are yellow or yellowish orange. The outer side is frequently also this color, but rarely may be a dark blue. The secondary pinnae are grey/bluish grey to dark blue. The yellow/ yellowish orange areas are surroundend by a tiny violet line that is easily visible in most animals, except in the darkest individuals. The rhinophoral sheaths are also grey/bluish grey to dark blue (Fig. 1A).

Internal morphology.— A general view of the internal anatomy can be seen in Figure 2. The buccal mass is elongate and tubular, well developed with a pair of elongate pouches opening into the digestive system at the junction of the oral tube and muscular pharynx (Fig. 3). The salivary glands are short and thick, entering on the buccal mass and flanking the esophagus. The labial cuticle lacks any armature. There is a well developed blood gland that is granular in texture. The radular formula of two specimens of 15 mm length (preserved) is 23 × 4.1.1.1.4. and that of the 30 mm specimen (preserved) has the formula 25 × 4.1.1.1.4. (Fig. 4A–C). The rachidian tooth (Fig. 4B) is broad, thin and curved at its base with three well-differentiated cusps. The inner lateral tooth



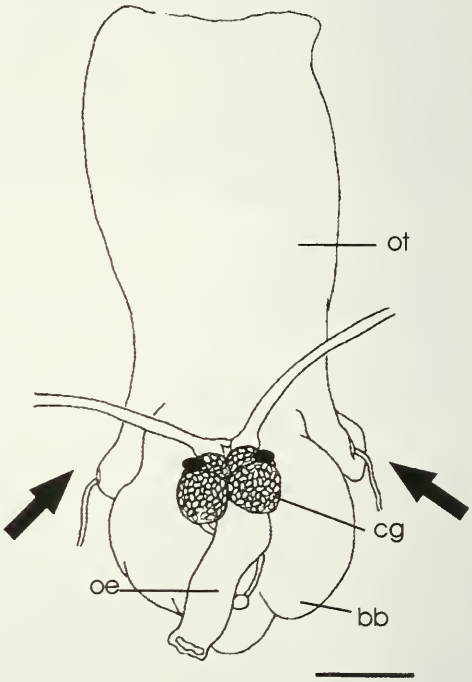


Figure 2 (left). *Roboastra europaea* García-Gómez, 1985. General arrangement of the internal organs. au = auricle, bb = buccal bulb, bc = bursa copulatrix, bgl = blood gland, ca = cephalic artery, cg = cerebral ganglion, hg+dg = hermaphrodite gland+digestive gland, in = intestine, oe = oesophagus, ot = oral tube, pe = pericardium, rn = rhinophoral nerves, vd = vas deferens, ve = ventricle, vg = vestibular gland.

Figure 3 (right). *Roboastra europaea* García-Gómez, 1985. Detail of the oral tube and buccal mass.

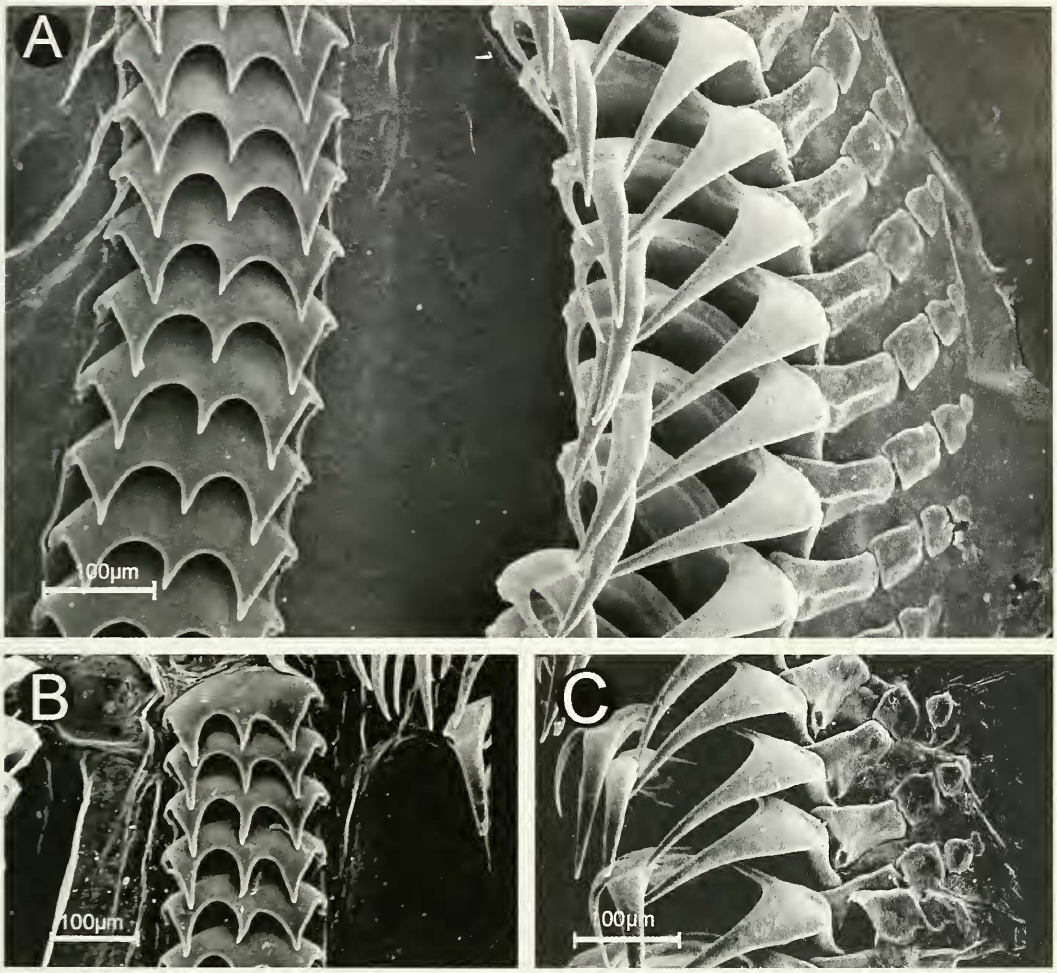


FIGURE 4. *Roboastra europaea* García-Gómez, 1985. CASIZ 166053, scanning electron micrographs of radula: A. Half-row of radular teeth. B. Rachidian teeth. C. Inner lateral tooth.

(Fig. 4C) has a strongly curved bifid inner cusp. The inner branch of this cusp is thin and smaller than the second. The outer cusp is undivided with a long spur-like denticle near the base. The remaining lateral radular teeth are quadrangular and lack cusps or denticulation and become smaller near the margin.

REPRODUCTIVE SYSTEM (Fig. 5).— The hermaphroditic duct widens into a S-shaped ampulla which has thick walls. The bursa copulatrix is rounded and larger than the seminal receptacle, which is elongate. The seminal receptacle has a short duct that connects to the vagina near the bursa. The deferent duct, which lacks a morphologically well-differentiated prostate, is long and coiled and ends in a dilated penial atrium. The vestibular gland is large with muscular walls, convex on one side and concave on the other. The penis is located within the distal end of this muscular portion, and it is armed with, at least, three different kinds of hooked and chitinous spines arranged in helicoidal rows. The types of spines and their arrangement on the penis are shown in Figure 6.

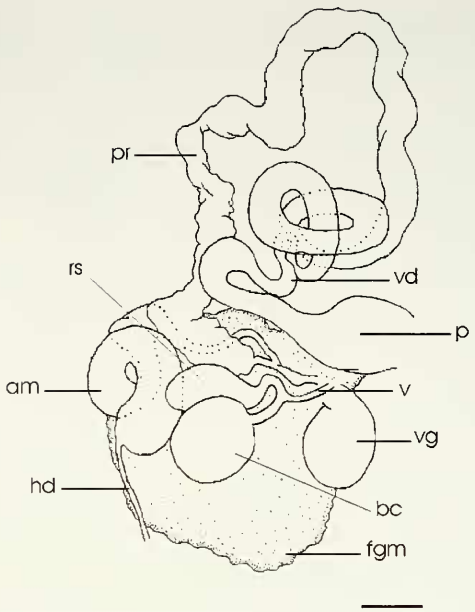


FIGURE 5. *Roboastra europaea* García-Gómez, 1985. Reproductive system, am = ampulla, bc = bursa copulatrix, fgm = female gland mass, hd = hermaphrodite duct, p = penis, pr = prostate, rs = receptaculum seminis, v = vagina, vd = vas deferens, vg = vestibular gland.

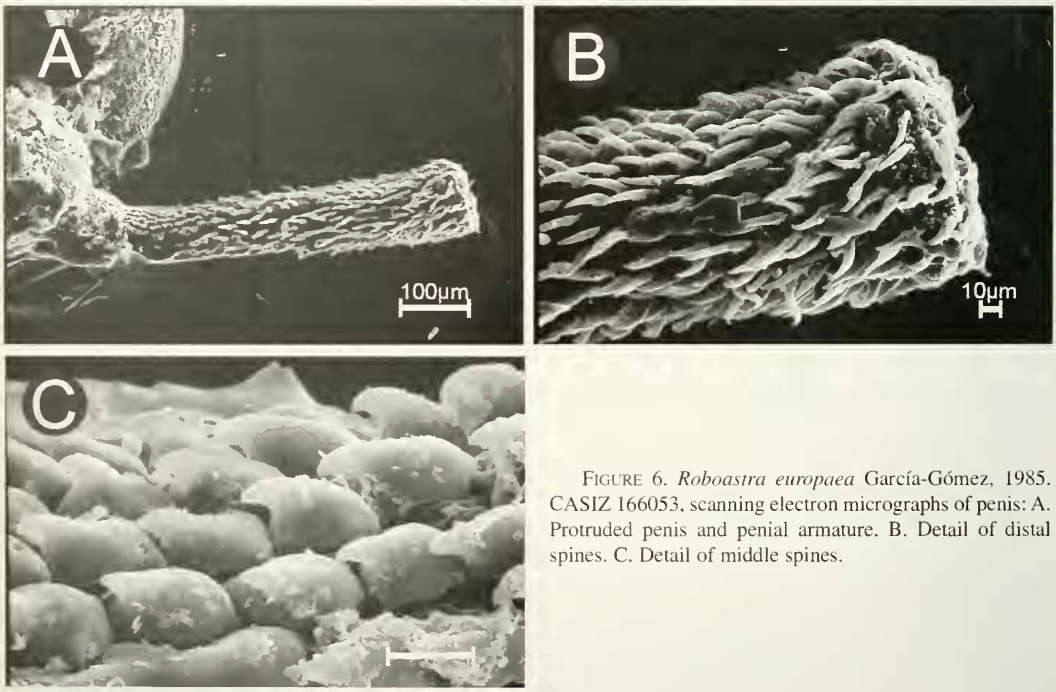


FIGURE 6. *Roboastra europaea* García-Gómez, 1985. CASIZ 166053, scanning electron micrographs of penis: A. Protruded penis and penial armature. B. Detail of distal spines. C. Detail of middle spines.

***Roboastra caboverdensis* Pola, Cervera, and Gosliner, sp.nov.**
(Figs. 1B, 7, 8, 9A–C, 10, 11A–D)

TYPE MATERIAL.— HOLOTYPE: CASIZ 166047, 1 specimen, 38 m depth, 15 miles NW Santo Antao Island, Cape Verde Archipelago, July 2002. PARATYPES: MMF35083, 1 specimen, Tarrafal Island. Cape Verde Archipelago. December 1998. P. Wirtz, 25 mm. MNCN. 15.05/46614, 2 specimen, 20 m depth, Banco Joao Valente, Boavista Island, Cape Verde Archipelago, August 2002, M.A. Malaquias, 26/30 mm (70 mm in life). CASIZ 166052, 2 specimen, 30 m depth, Banco Joao Valente, Boavista Island, Cape Verde, August 2002, M.A. Malaquias, 31/37 mm (70 mm in life). MNCN. 15.05/46617. 3 specimens, Boavista Island, August 2002, C. Grande, 13/15/18 mm. CASIZ 166050, 1 specimen, Sao Vicente, October 2002, G. Calado, 20mm. Specimens were collected on rocks and were measured preserved.

ETYMOLOGY.— The name *caboverdensis* refers to the Cape Verde Archipelago where this species is found.

DISTRIBUTION.— Thus far, known only from Cape Verde Archipelago.

EXTERNAL MORPHOLOGY.— The body is elongate and limaciform with a long and pointed posterior end of the foot. The preserved animals are 10–40 mm in length. The living animals (Fig. 1B) may reach 70 mm in length. The body surface is strongly wrinkled. The foot is linear. The head is rounded with a pair of conical, completely retractile, perfoliate rhinophores with approximaly 35 tightly packed lamellae. The oral tentacles are strongly developed and dorsolaterally grooved along a part of their length. There are five non-retractile tripinnate gills, with the three anteriormost being more highly developed. The gills form a semicircle surrounding the anal papilla. The genital pore opens on the right side, midway between the gills and rhinophores. The ground color is dark blue, almost black. A wide yellow submarginal band follows the inner notal edge. This band is interrupted in some specimens. A second yellow band arises from the former, just in front of both rhinophores and surrounds the inner side of their sheaths, continuing to the rear to the base of the gills. These bands can bifurcate at their origin. In this case, the sheath of the rhinophores is surrounded by the shorter branch. In either situation, these bands surround the gill to join each other posteriorly. These last bands can be interrupted or continuous. The edge of foot is also bordered by a wide yellow band. On the sides of the body, just below the notal edge, there is a line of the same colour that bifurcates and surrounds the genital pore, continuing to the end of the posterior end of the foot. Both branches can be continuous or not. Moreover, several yellow lines, varying in number and length, are arranged between the dorsal and the foot bands. The oral tentacles, the rhinophores and the posterior part of their sheath are also blue-black. The gills are blue-black, but the inner and outer sides of the rachis of each one have a yellow line between them.

INTERNAL MORPHOLOGY.— The general arrangement of the internal organs is shown in Figure 7. The anterior digestive tract begins with a long thick-walled muscular oral tube, that continues into the buccal mass. At their junction, a pair of elongate pouches open into the digestive system (Fig. 8). There is a pair of small, short and wide salivary glands on the buccal mass, flanking the esophagus. The radular formula of two specimens of 70 mm (in life) is $33 \times 3\text{-}4.1.1.1.3\text{-}4$ (Figs. 9A–C). The rachidian tooth (Fig. 9B) is broad, clearly curved at the base, having three well-differentiated cusps. The inner lateral tooth (Fig. 9C) is hooked with two well developed elongate cusps. The inner one is very long, having sharp and curved edges on the internal side and a prominent projection (see the arrows Fig. 9A) on its outer edge. The outer lateral teeth (3 to 4) are smaller and quadrangular without prongs, and decreasing in size from the inner to the outer side of the radula. A labial cuticle is present, but lacks armature.

REPRODUCTIVE SYSTEM.— The reproductive system is shown in Figure 10. The hermaphro-

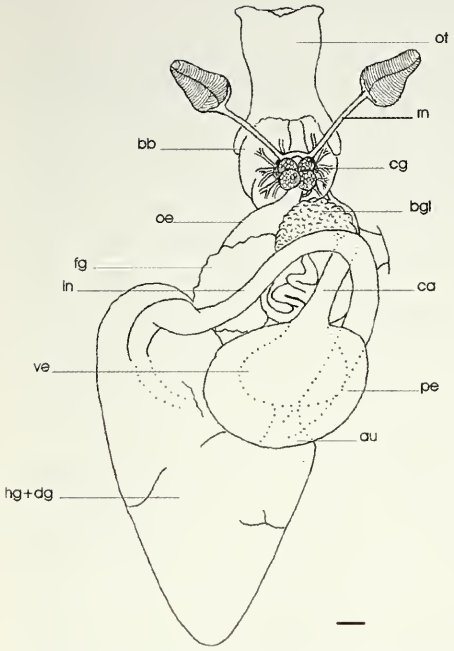


FIGURE 7. *Roboastra caboverdensis* sp. nov. General arrangement of the internal organs. au = auricle, bb = buccal bulb, bgl = blood gland, ca = cephalic artery, cg = cerebral ganglion, fm = female gland, hg+dg = hermaphrodite gland+digestive gland, in = intestine, oe = oesophagus, ot = oral tube, pe = pericardium, rn = rhinophoral nerves, ve = ventricle.

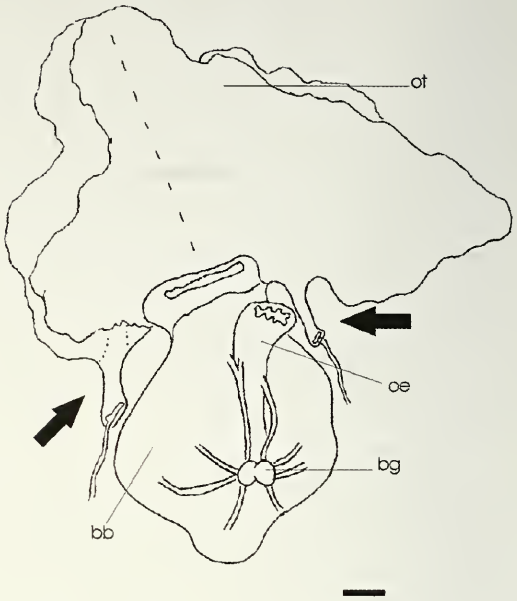


Figure 8. *Roboastra caboverdensis* sp. nov. Details of the oral tube and buccal mass, bb = buccal bulb, bg = buccal ganglion, oe = oesophagus, ot = oral tube.

ditic duct has an "S" shaped ampulla that continues into the spermoviduct. The vas deferens is long and coiled, with a uniform width. It is slightly narrower in the prostatic part. It ends in a dilated penial section. The penis is armed with, at least, three different kind of spines arranged in helicoidal rows. Types of spines and their arrangement on the penis are shown in Figures 11A–D. The bursa copulatrix is rounded and the seminal receptacle elongate. The seminal receptacle joins with the vagina, near the bursa via a short duct. The vagina is short and straight, opening into the genital atrium, near the vestibular gland. This gland is very well developed, flattened, with muscular walls.

DISCUSSION

In 1985, García-Gómez described the first species of the genus *Roboastra* in the Atlantic Ocean, from the Strait of Gibraltar. The original description of the external anatomy, radula and reproductive system of *Roboastra europaea* is in agreement with our specimens of this species; however, our specimens exhibit a different pattern of coloration than has been previously described for this species (Schick 1998; Megina 2000; García-Gómez 2002:224, phot. 44[2]; Sanchez 2001). Moreover, it is confirmed that the spicules of the surface of the mantle mentioned in the original description do not exist (perhaps they were an artifact of preservation). A pair of small, short and wide salivary glands on the buccal mass flanking the esophagus are described for the first time. These salivary glands are present in the other two genera of the subfamily Nembrothinae,

[2] The colour pattern supplied by García-Gómez (2002) is an adaptation from his original description (García-Gómez, 1985), with additional and later information, although the specimens included in the "Material" section are the same in both references.

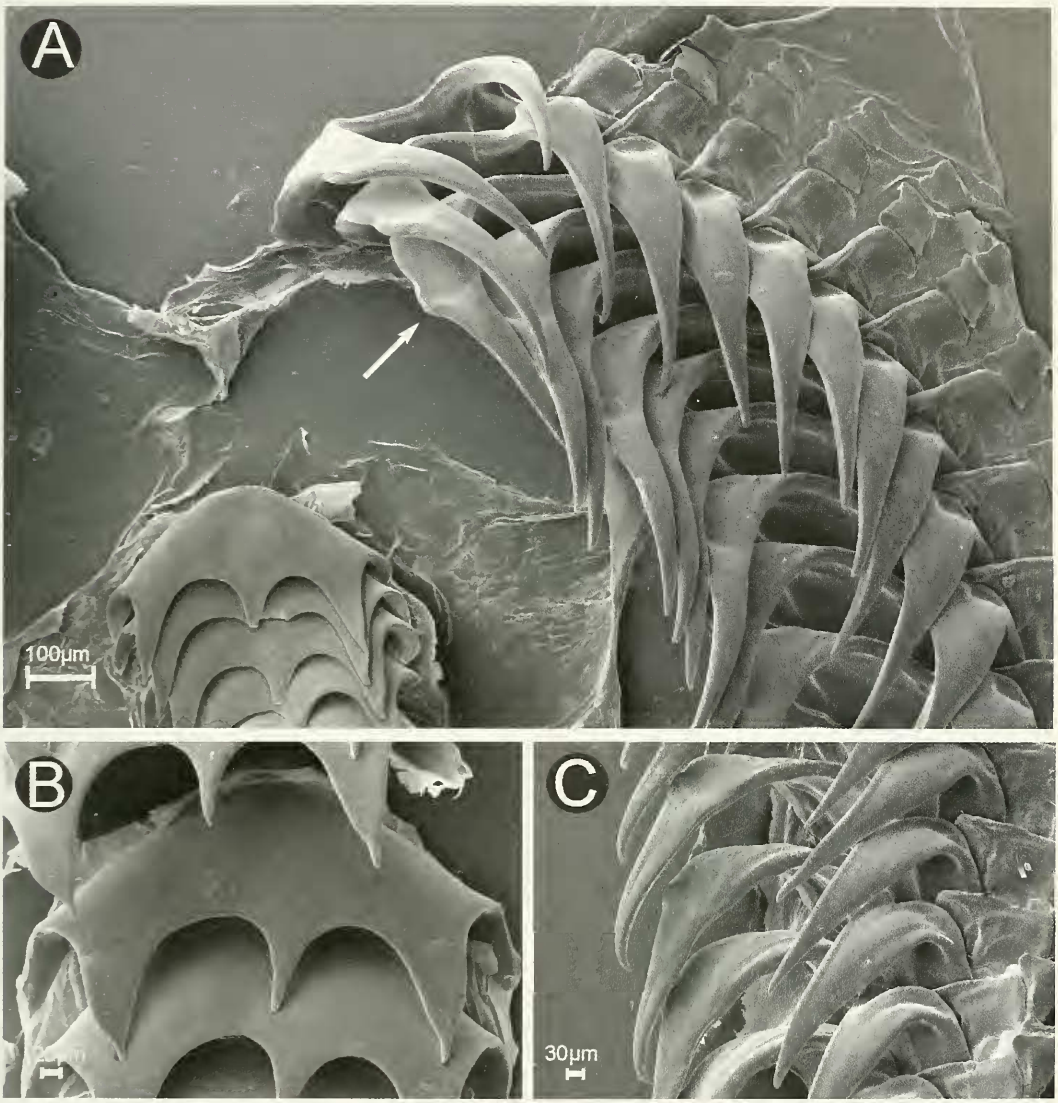


FIGURE 9. *Roboastra caboverdensis* sp. nov. CASIZ 166052, scanning electron micrographs of radula. A. Half-row of radular teeth. B. Rachidian teeth. C. Inner lateral tooth.

Nembrotha and *Tambja*, but in these they are longer and more robust than in *Roboastra*. García-Gómez (1985) did not describe the presence of a pair of elongate pouches that open into the digestive system at the junction of the oral tube and muscular pharynx. The function of these structures is still unknown; nevertheless, Burn (1967) described similar structures in *Roboastra gracilis*.

The external and internal features of *Roboastra caboverdensis* permit us to distinguish it from its congeneric Atlantic species. The arrangement of the yellow lines or bands in both species is different and are more numerous and tightly packed in *R. europaea*. Moreover, *R. europaea* has two colour phases, light and dark (see Cervera et al. 1988 and Ocaña et al. 2000, for a colour picture of the light phase).

Regarding the internal anatomy of both species, the base of the rachidian radular tooth is more

curved in *R. caboverdensis* and the upper cusp of the inner lateral radular tooth is bifid in *R. europaea* while in *R. caboverdensis* it is simple. The reproductive system of *R. caboverdensis* is similar to that described for *R. europaea* except that the portion of the ejaculatory duct near the prostate is more highly convoluted in *R. europaea.* The penis in both cases is armed and the spines, of three different sizes and shapes, are implanted in helicoidal rows. In both *R. europaea* and *R. caboverdensis*, the distal two-thirds of the penis has elongate, curved spines, and the basal spines are medium sized but straighter than the distal ones. Between them, there are some rows of short, curved spines, a few with little spines just behind them.

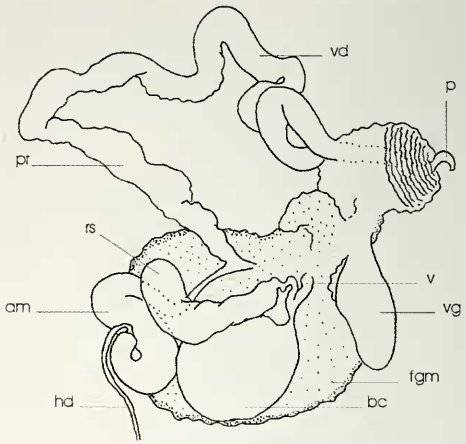


FIGURE 10. *Roboastra caboverdensis* sp. nov. Reproductive system, am = ampulla, bc = bursa copulatrix, fgm = female gland mass, hd = hermaphrodite duct, p = penis, pr = prostate, rs = receptaculum seminis, v = vagina, vd = vas deferens, vg = vestibular gland.

There is another dark blue/black with yellow bands or lines nembrothid in the Cape Verde Archipelago, *Tambja simplex* Ortea and Moro, 1998. However, the yellow pattern of this species has few lines with a different arrangement, and the internal anatomy (salivary glands, labial cuticle, radular teeth and reproductive system) are characteristic of *Tambja* (Ortea and Moro 1998; Cervera et al. 2000).

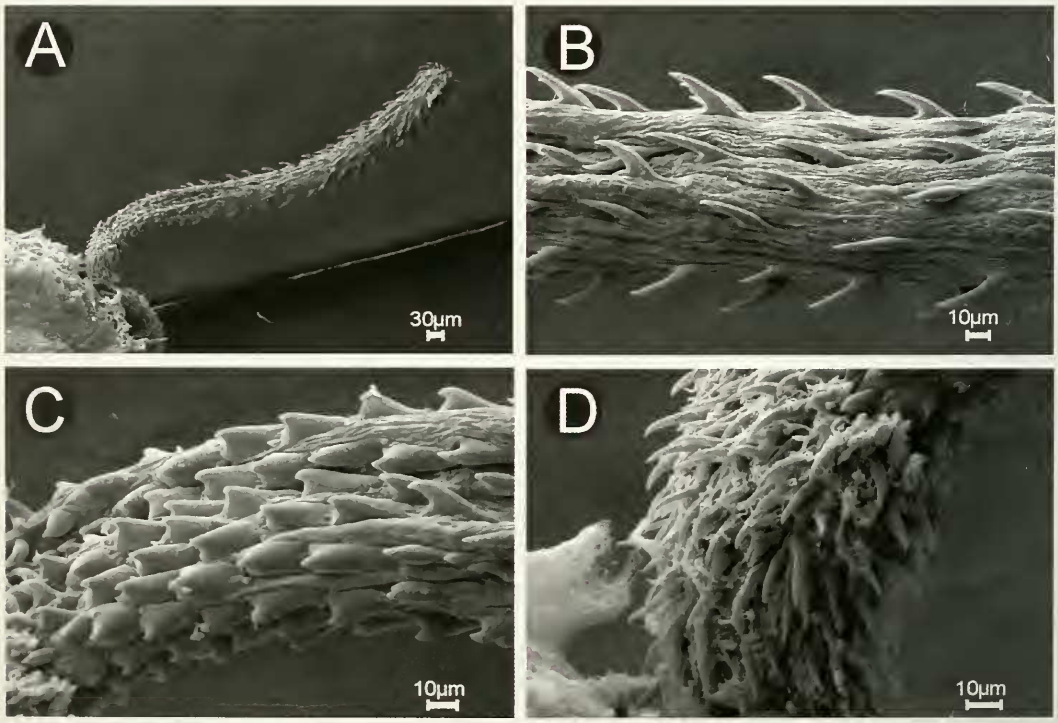


FIGURE 11. *Roboastra caboverdensis* sp. nov. MNCN 15.05/46614. A. Protruded penis. B. Detail of distal spines. C. Detail of middle spines. D. Detail of basal spines.

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